Recommendations for Future Interlinkage Assessment

van Drunen, M.A.; Kuik, O.J.; Giljum, S.

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Indicator-based evaluation of interlinkages between different sustainable development objectives

Recommendations for Future Interlinkage Assessment

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Prepared by:	Michiel van Drunen, Onno Kuik and Stefan Giljum
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Contents

1. Introduction

This report is the seventh deliverable of the Workpackage 2 in the European Commission funded INDI-LINK project (INDI-LINK, 2007). In Deliverable 2.1 (Van Herwijnen, 2007), we assessed thirty-one methodologies, methods and tools (MMTs) that are potentially capable of identifying linkages (synergies, trade-offs) among the sustainable development indicators (SDIs) analysed in Workpackage 1 (Hak *et al.* 2007). These assessments were based on literature reviews and expert judgments. Deliverable 2.4 (Van Drunen et al., 2008) discussed studies that actually applied the MMTs on subjects relevant for EU sustainability. It also developed a decision-tree for the users of the MMTs, which guides users with specific questions to the best available options in terms of available methodologies and tools.

There are only few MMTs that have proven to be able to identify quantitative and strong interlinkages including GINFORS (Global INterindustry FORecasting System) and DEAN (Dynamic applied general Equilibrium model with pollution and Abatement for the Netherlands). A limited number of MMT case studies (including MCA, GVAR[1] and DEAN) dealt with social indicators such as literacy rate and life expectancy.

Deliverable 2.5 (Van Drunen et al., 2009) investigated future interlinkages. It addressed the question: are the selected MMTs capable of establishing scores on sustainability indicators in the coming ten years *and* interlinkages among these scores? The selected MMTs were MCA (multicriteria analysis), Global Vector AutoRegression (GVAR), the econometric input-output model GINFORS, and DEAN and Advanced Sustainability Analysis (ASA). Again we took a case study approach that enabled us to show what the MMTs are capable to in practice.

This report elaborates the policy implications of Deliverable 2.5. It discusses its main findings in Chapter 2 and provides recommendations for future research in Chapter 3. Chapter 4 discusses some policy implications.

1 In previous reports referred to as *VAR|VECM*.

2. Future interlinkages

Van Drunen *et al.* (2009) illustrated how MCA (Multicriteria Analysis), Global Vector Auto-Regression (GVAR), the econometric input-output model GINFORS, the Dynamic applied general Equilibrium model with pollution and Abatement for the Netherlands (DEAN) and Advanced Sustainability Analysis (ASA) perform in the examination of actual policy scenarios. Figure 1 depicts a decision tree for deciding which MMT (in the framework of all MMTs considered in INDI-LINK) would be most suitable for specific purposes. It shows that GVAR and ASA can be used for quantitatively assessing linkages that between indicators that provide information about the state of sustainable development in a region. DEAN, GINFORS and MCA assess specific policies options. The latter is able to rank such options, whilst DEAN and GINFORS model outcomes show the distances to sustainability targets. Below we summarize the overall results of the policy scenarios that were examined in Van Drunen *et al.* (2009).

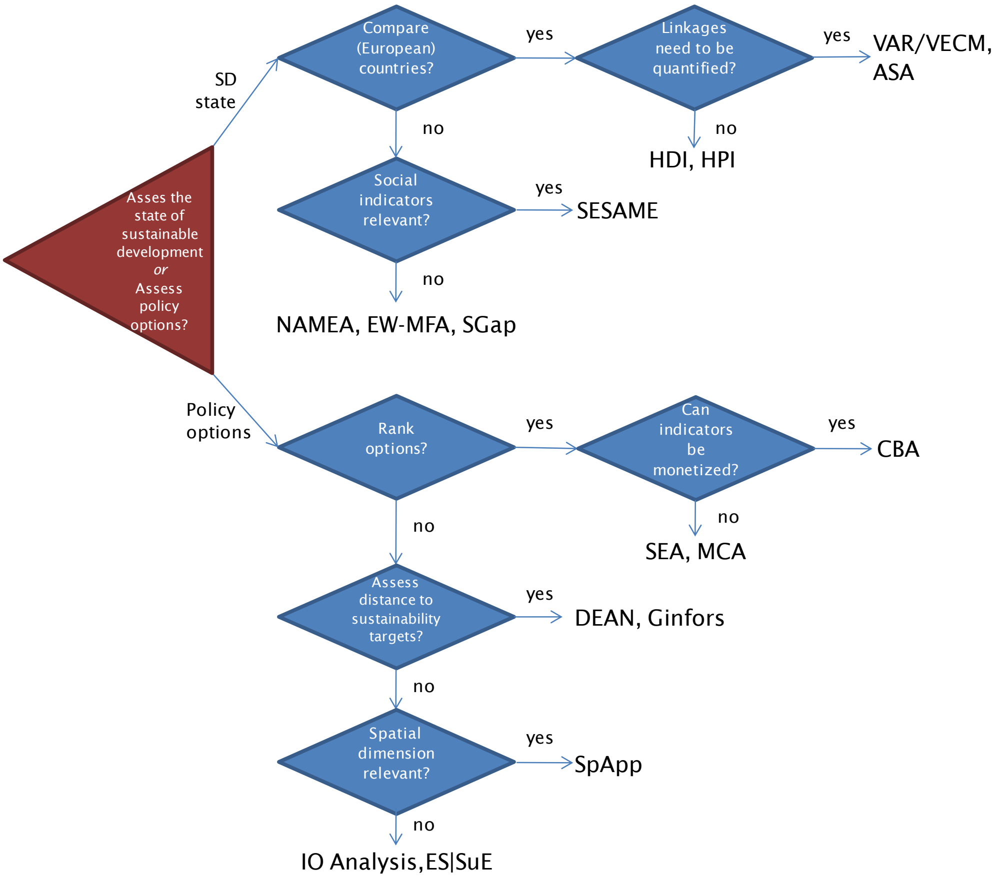

Figure 1 Decision tree for the application of the MMTs discussed in this report based on the questions to be addressed. The scheme is explained in detail in Van Drunen et al. (2008).

Multi-criteria Analysis was used to rank four future electricity production alternatives for the Netherlands with the help of a set of criteria that are closely related to a number of sustainable development indicators from the economic and environmental pillars. An interesting side product from the multi-criteria analysis is the correlation matrix of the criteria that is derived from the effects table. The correlation matrix shows trade-offs and synergies between the criteria of the decision-making problem. Because the criteria were closely related to sustainable development indicators, the correlation matrix suggests the nature of the interlinkages among sustainability indicators, but only, of course, within the context of the specific decision-making problem investigated. In that decision-making problem, there appeared to be high positive correlations between natural gas depletion and the reduction of SO_2 and PM_{10} emissions (which seems to point at a trade-off) and high negative correlations between the reductions of CO_2 and NO_x (trade-off), and a high negative correlation between costs and PM_{10} emissions (synergy). These synergies and trade-offs are specific for this decision-making context, however, and cannot be easily generalized to other contexts. For example, in this case there appears to be no significant trade-off between costs and CO_2 emissions reduction. A generalization of this result to a broader policy context would seem to be inappropriate.

The GVAR model can be used to explore statistical relationships among sets of sustainability indicators. The model has been successfully applied to forecasting purposes in the area of financial and economic analysis, and could in principle be applied to explore future interlinkages among a broad array of sustainable development indicators. In the case study, GVAR examined interlinkages between (the growth rates of) GDP per capita, CO_2 emissions per capita, energy use per capita, life expectancy at birth, and the unemployment rate. The analysis was first done with the UN World Development Indicators for EU15 for the period 1980-2005. The case study briefly presented statistical relationships between the variables for Germany. It should be noted, however, that these relationships describe short-term (1 year) rather than long-term interlinkages. The case study discusses what steps need to be taken to identify long-run relationships. The GVAR model clearly looks like a promising tool to find significant statistical relationships among diverse indicators of sustainable development, but there is still much work to be done, both with respect to expanding the empirical database and with respect to providing a theoretically coherent framework for modelling the interactions between sustainable development indicators.

GINFORS is a large-scale, global, economy-energy-environment simulation model, encompassing various dimensions of sustainable development. GINFORS' coverage of sustainable development indicators from the economic and environmental pillars is relatively large. Currently the model includes twelve sustainable development indicators from the EU SDI set, including the headline indicators of the themes: socio-economic development; sustainable consumption and production; climate change and energy; and sustainable transport. Another thirteen indicators (among which the headline indicator for demographic changes) could be included in a relatively easy way. Detailed information on the sustainable development indicators is presently available for 19 EU countries (EU15 + Czech Republic, Hungary, Poland and Slovakia). Two environmental policy scenarios were evaluated with GINFORS: a reference scenario and a scenario in which the EU would unilaterally reduce its emissions of greenhouse gases by 20% by 2020. A comparison between the scenarios reveals trade-offs and synergies between the economic and environmental indicators (especially greenhouse gas emissions), but there are differences across countries. Because of the many indicators and countries, the results of the simulations provide a rich set of quantitative interlinkages among the indicators.

The DEAN model is a dynamic applied general equilibrium model for the Netherlands – a small open economy. DEAN covers detailed information on the emissions of greenhouse gases and a number of environmental pollutants and on the abatement options to mitigate these emissions. It contains seven variables that are closely connected to sustainable development indicators from the economic and environmental pillars. DEAN evaluated four policy scenarios – a reference (benchmark) scenario and three policy scenarios that are all based on the achievement of national environmental policy targets. The benchmark scenario of DEAN itself is somewhat arbitrary – DEAN *assumes* a balanced-growth path in which all economic variables grow at the same rate. The growth rate of emissions is governed by exogenous changes in pollution per unit of economic activity (pollution efficiency rates). Of interest in the policy scenarios are the relative deviations of the variables and indicators from the benchmark path. The analysis with DEAN suggests that the precise form of the future interlinkages depends on three major aspects: (i) the assumptions made with respect to the model specification and parameterization, (ii) the benchmark projection, and (iii) key characteristics of the underlying environmental policies, with respect to its efficiency per theme as well as with respect to its integration across different environmental themes. In general, the analysis suggests that synergies between economic and environmental sustainable development indicators will be greater, the more flexible and integrated the environmental policies are.

The ASA method is a decomposition method that can be applied to a wide variety of sustainable development indicators. The ASA method is a useful tool for understanding historic trends in sustainable development indicators over time. It 'decomposes' these trends of the target indicator in relative contributions of explanatory factors. One or more of these explanatory factors can themselves be sustainable development indicators, so that interlinkages between the target indicator and the explanatory indicators can be established. The ASA method can be used for *what-if* kinds of scenario analysis. However, most decomposition methods including ASA suffer from some technical problems in the interpretation of the results of these scenario analyses if 'large' changes are evaluated (and interaction among the explanatory factors is strong). The results may also be difficult to interpret if the decomposition is not based on some well-established underlying model so that the meaning of some of the explanatory factors remains unclear. Existing models deal mainly with energy consumption or CO_2 emissions, but they are relative simple: there is only one explaining variable – GDP. Traditionally the interaction between energy consumption and GDP has been very strong. Hence the interpretation of results is complicated, because the underlying models are usually too simplified. One aim of the ASA approach is to develop models by identifying more contributing factors.

Our case studies (Van Drunen et al, 2008; Van Drunen et al, 2009) suggest that integrated assessment models (specifically GINFORS and DEAN) are most suitable for assessing trade-offs and synergies between sustainability indicators as a result of (proposed) national or international policies. For project level decisions multi-criteria analysis or cost-benefit analysis seems most appropriate. In most cases, these methods would require additional models to enable them to assess future linkages.

The next chapter will draw the methodological conclusions from these case studies and derive recommendations for improving the analysis of interlinkages in the future.

3. Research recommendations

The above observations illustrates that the nature of the interlinkages is not automatically revealed by the tested models. The identification of future interlinkages between sustainable development indicators requires additional analysis, such as statistical analysis of modelling results. If one has an idea (a theory) about the nature of the interlinkages, cause-effect relationships between the trends of different indicators can be established. This idea can be simple: a simple correlation between two SDIs (MCA), or complex: embodied in a large simulation model (GINFORS). Some ideas can be tested on historic data (GVAR), but this is always subject to methodological difficulties and data constraints. Moreover, interlinkages that held in the past, may not automatically hold in the future. Future interlinkages are dependent on future policy scenarios (including no-policy scenarios); this interdependence can be represented in relatively simple models (ASA) or complex applied general equilibrium models (DEAN). All potential future interlinkages are therefore conditional and uncertain, but – in relative terms – we have better 'ideas' or 'theories' on future interlinkages between indicators within and between the economic and environmental pillars of sustainable development than between the social pillar and the other pillars.

Table 1 provides an overview of the main findings and recommendations. The challenge of future research in this area is to develop better 'ideas' on interlinkages, especially related to indicators from the social pillar, to test these ideas against historical data, and to include them in applied assessment models. Particularly important are the consequences of sustainable development policies for specific income groups: are the burdens of the transition into a low-carbon eco-efficient society shared fairly?

A major challenge would be to enable policymakers or even informed citizens to actually operate the models. At the moment, models like GINFORS and DEAN can only be run by experienced researchers. Development of simplified user interfaces, which allow designing and running scenarios without any technical knowledge on the algorithms of the models, should therefore be an important part in the further development of these models.

An important prerequisite for the planning, implementation and evaluation of policy and industry measures is the linkage of the macro and meso level indicators and findings to micro level options, i.e. to specific technologies, product systems and company performance. This relates to monitoring and retrospective evaluation, but also to the assessment of improvement potentials (technological and institutional). Therefore, a consistent cross-level application of the indicators is needed, and moreover, a societal learning process which involves the application of MMTs across various levels (Bringezu et al. 2009).

Given the uncertainty that surrounds sustainable development policies and sustainable development itself, it would also be a challenge to better integrate uncertainty analysis and risk-based approaches in the assessment of future linkages. E.g. by applying consistent sets of socio-economic scenarios the 'uncertainty space' can be explored. Examples of such scenarios are Foresight Futures (2002), GEO-3 (UNEP, 2002) and SRES (IPCC, 2000). The FORESCENE prototype of meta-model used Bayesian Network methodology in order to consider the 'probability range' of scenarios (FORESCENE, 2009).

Table 1 Future interlinkages assessment: main findings and recommendations.

Area	Finding	Recommendation
Theory	A solid theory on the interlinkages between the different SD indicators and trends has not been developed so far. Also a theory for a multi-level SD indicator framework is lacking.	Commission research devoted to the elaboration of a theoretical framework of interlinkage assessment. This should include a multi-level application (macro-meso-micro) of SD indicators and their interlinkages.
Data	Statistical and decomposition methods as well as econometric simulation models require sufficient historical data sets. In the cases investigated these data sets were not always available.	To extend the time series of SDI to the past, if possible. To ensure that all data underlying SDIs are collected on a yearly basis in the future.
	Statistical and simulation models often need data in different dimensions than those of the SDI data set (e.g. levels instead of percentage changes)	Allow the user to select alternative dimensions of the data, including the original dimensions and the absolute numbers.
	For certain applications (e.g. decomposition) important (intermediate) indicators were missing from the SDI set.	Consider whether it is possible to define and select related indicators within one theme through the use of the driver-pressure-state-impact-response (DPSIR) framework.
	For many SDIs, there is a significant time lag in the publication of statistical data. Recent trends can often not be analysed due to the lack of timely data.	Develop methodologies to provide solid estimates for the current values of data underlying the SDIs.
	Robust social data is in many cases not available for interlinkage assessment. Important analyses, such as distributional impacts of SD policies, can therefore not be performed.	Increase the availability of social data for statistical and modelling purposes.
Models	There are few empirical models that allow quantifying future interlinkages among sustainability indicators.	Support quantitative modelling in this area. Support the further development of models, which are based on integrated economic-environmental-social accounts.
	The models that quantify future linkages typically focus on synergies and trade-offs between economic and environmental indicators. Indicators from the social pillar are under-represented.	Support the inclusion of social SDI in applied modelling.
	Many of the most powerful models can only be operated by experts.	Develop user interfaces, which allow users to develop and run model calculations without having to understand the model in all its details. Develop simplified models that can be operated by policymakers or informed citizens.
Scenario assumptions	Future interlinkages always depend on underlying scenario assumptions about the future evolution of socio-economic and technological parameters and policies that affect those parameters.	Formulate or select standard socio-economic-technological scenarios to be used when using SDI data for scenario analysis.
	It should be noted that interlinkages that held in the past, may not automatically hold in the future.	See above

Assessment framework	There is no single, best MMT to analyse interlinkages between SDIs in all its diversity. The choice of the MMT to assess SDIs and sustainability policies depends on the policy scale (EU, national, local), the interlinkages to be investigated (pillars, strong/weak, causality), (historical) data availability, and the intended use of the study (strategic, policy decision).	Provide guidance on modelling approaches for users of SDI data. Test different existing methods specifically for interlinkage assessments to increase knowledge on specific advantages and disadvantages of certain methods.
	The scheme of Figure 1 can be helpful to decide which MMT may be suitable to support policy decisions.	Provide guidance on modelling approaches for users of SDI data.

4. Policy recommendations

Integrated Assessment Models

Our case studies (Van Drunen et al, 2008; Van Drunen et al, 2009) suggest that coupled environment-economy models (specifically GINFORS and DEAN) are most suitable for assessing trade-offs and synergies between sustainability indicators as a result of (proposed) national or international policies. For project level decisions multi-criteria analysis or cost-benefit analysis seems most appropriate. In most cases, these methods would require additional models to enable them to assess future linkages. GVAR may be further developed to assess (short term) linkages between sustainable development indicators. ASA was considered not very suitable for making future assessments.

The integrated assessment model outcomes generally indicate trade-offs between environmental policies and economic indicators. This is in line with what standard environmental economics text books say. E.g. Kahn (2005: 188) concludes that: "[...] a stricter environmental policy will have a negative direct impact on the economy, because resources that could be used elsewhere are devoted to production."

However, model exercises with GINFORS and other models reveal that the more flexible and integrated the environmental policies are, the lesser the negative impacts are on the economy. The specific policy design and especially the revenue recycling mechanism is very important and can even change the sign of the results, i.e. a trade-off between CO_2 reduction and GDP growth could become a synergy, if the policy target is reached in the same model with another (better) policy design. Furthermore, model outcomes suggest that lesser negative impacts on the economy are expected if more countries set the same greenhouse gas emission reduction targets (Lutz and Meyer, 2009). To minimize trade-offs between environmental and economic indicators it is recommended to promote integration, flexibility and international co-operation in sustainable development policies. Finally, it should be noted that several studies revealed that in particular resource (material, energy) efficiency policies allow reducing costs for enterprises and have positive growth impacts (Dosch, 2005; Giljum et al., 2008).[2]

Synergies and trade-offs are unique and small adaptations to certain policies (e.g. in the revenue recycling mechanism as indicated above) may have large impacts on the magnitude of the interlinkages. The uniqueness was shown in the MCA case that resulted in a counterintuitive result: no significant trade-off between Costs and CO_2 emission reduction (Van Drunen et al, 2009: Section 2.5). It was concluded that this result was specific for the alternatives chosen. Therefore, it is impossible to extrapolate the results of particular policy assessments to other policy fields.

The structure of the economy

The DEAN model results showed that policy makers should pay attention to the economic opportunities induced by stringent environmental policies. Analysis of environmental policy mostly focuses on the economic threats of these policies, *i.e.* on sectors that are affected by the policy. The opportunities that environmental policy creates for other production sectors, in-

[2] The issue of policy design is further elaborated in Workpackage 3 of INDI-LINK, specifically in Dresner and Chassais (2009).

cluding the abatement sector and potentially also some services sectors, are often ignored. The implementation of environmental policy boils down to a reallocation of resources in the economy, not just a shrink of economic activity. Consequently, the macro-economic impact of stringent environmental policies is relatively modest, though certainly not negligible, and the growth rate of the economy is only temporarily affected.

Moreover, changes in sectoral structure of the economy (economic restructuring) are as important for reaching the environmental policy targets at minimum costs as the implementation of technical abatement measures. Both sources of emission reductions are vital in terms of their contribution to achieving the policy targets as well as in terms of the associated costs. More stringent environmental policies imply more emphasis on economic restructuring as a means to achieve the targets. If policymakers impose restrictions on the changes in sectoral structure, *e.g.* by providing additional support to specific sectors or exempting some economic activities from the policy, they have to realise that the macro-economic costs of the policy will increase substantially and/or that the policy target may not be reached.

Social indicators

This report focused on environment – economy interactions, mainly because the models applied in this study specifically dealt with environmental and economic indicators. Most integrated assessment models do not integrate social indicators, apart from employment related indicators. GINFORS is capable of including the indicators early school leavers, EU imports from developing countries and total EU financing for developing countries, but these indicators were not included in the case study in Van Drunen et al. (2009: 45). We recommend including these indicators in future assessments, and also other social indicators related to e.g. health and education. Of specific interest are the impacts of sustainable development policies on specific income groups.

Uncertainty

Finally we want to re-address the issue of uncertainty that was already introduced in Chapter 3. Nils Bohr, Nobel laureate in physics, already said: “Prediction is very difficult, especially if it’s about the future.” The models we investigated assume that the future society is similar to our current society, i.e. that the parameters in the relationships that connect the sustainability indicators remain the same. This assumption may well be correct in the short term but will probably not be correct anymore in the long term. The DEAN study also concluded that any prediction on future interlinkages will always be conditional upon fundamentally unknown future technological (and institutional) progress.

An approach advocated in the field of climate change adaptation is to seek for ‘robust’ or ‘no-regret’ policies, i.e. policies that would ‘work’ in all kinds of future societies. An example of such a policy is beach nourishment for the Dutch coast: this is a relatively cheap option for coastal protection that works well in most socio-economic and climate scenarios (Deltacommittee, 2008). This approach may also be applicable in the field of other sustainable development policies, but therefore it is required to develop internally consistent scenario sets that cover a broad ‘future space’. Hence the scenarios represent different worldviews: typically combinations of international governance options (co-operation or not) and market related options (liberalization or not). These scenarios generally do not include new policies to allow investigating the impacts of such policies on society (e.g. WLO, 2006).

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